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AP Environmental Science in the Lab

The College Board (a division of ETS) has made a conscious decision to define the AP Environmental Science course as having a laboratory component. This means that laboratories you've performed throughout the year in your course will be tested in some way on this exam.

On the other hand, the College Board also decided to be incredibly flexible about the particular labs that should be covered in the course. The variety of different labs that can be performed gives students opportunities to explore various topics in environmental science; this also allows instructors the freedom to adapt their course laboratories to their geographic locations, which can make the course more interesting for students.

However, there are several skills that you will be expected to have gained through participating in laboratories in your course, and the College Board describes these skills in the following way. You should be able to

- make your own observations
- research known data (including library research)
- make a hypothesis
- formulate a prediction
- design an experiment
- gather data and formulate results
- draw conclusions

In other words, you will be expected to be familiar with the scientific method. Although scientists work in many different ways, and often one experiment turns into another without the formal recording of a hypothesis or results, you should understand that the scientific method was created in order to provide a very basic outline for scientific investigation.

During your AP Environmental Science course, you have probably been in the lab a number of times and completed many different types of laboratories. You've probably written lab reports and handed them in to your teacher, and you may have had to do a class presentation or two. As we discussed above, the lab experiences you had in your AP Environmental Science course are probably wildly different from the lab experiences that other students have had at different schools—and this is only partly due to the fact that the College Board didn't give your teacher a list of required labs.

On the AP Environmental Science Exam, you could be asked a number of different types of questions in which the lab component from your class will be helpful. However, you won't be able to get full credit simply by remembering the details of what you did in a particular lab. You will have to use your critical thinking skills to answer these questions.

LET'S TRY ONE—A SAMPLE FREE-RESPONSE QUESTION INVOLVING A LAB

For example; a free-response question on the exam might look a lot like the one below.

2. The county range management office has just received a federal grant to study the breeding success of hawks in your area and you—their student intern for the summer—have been chosen to design and perform the research. The range office wants to know how the hawk population at the state prairie reserve compares with the hawk population on the federal grazing land and the private ranch land. The state prairie reserve allows no grazing, cutting, or control burns. The antelope herd that grazed there until a year ago had to be destroyed because of an illness in the herd. Any lightning strikes are extinguished as quickly as possible. The federal grazing lands are rented out to local ranchers whose private lands border the federal land. The management of these lands allows for a specific number of grazing days per year from the mid-spring until the mid-summer—but no cutting, even of damaged trees, and accidental burns are extinguished promptly. Private lands, of course, can be managed as desired.
   - (a) Identify and describe what factor or factors will enable you to judge the hawks' breeding success.
   - (b) Design a plan of action for determining the hawks' breeding success in the three areas. What will be your control?
   - (c) Describe how the land management plans of each of the three areas would affect the success of the hawk population.
   - (d) Discuss why a predator such as the hawk would provide evidence of a successful land management plan.

You may be saying to yourself that you know nothing about hawks or the prairie other than what you learned from watching *Little House on the Prairie* reruns. But before you decide that you can't answer this question, think about what you do know.

Take a minute to reread the passage and then the questions. Look at part (a). How do you think you could determine the success of a bird population—or any population, for that matter? Well, one surefire way to assess the health of a population is by seeing how many offspring they produce, and how many of these survive to reproductive age. So, for hawks, the number of offspring produced could be determined by counting the number of eggs laid; the number of offspring that survive to reproductive age could be approximated by counting how many fledgling leave the nest.

So, in answering this part of the question you could cite these two methods, including any others you can think of. However, make sure you don't get overzealous—don't list too many possible sources of data because after all, you are just one person, you're there for one summer, and the prairie is a big place!

In part (b), you're asked to design a plan of action. You know what your dependent variable is—the success of the hawk population—and you know how you are going to judge this success—by the number of eggs laid and the number of fledglings that leave the nest. The reasoning behind this proposed line of action is that the more eggs laid by individuals, the greater the health of the population. Rates of egg-laying also provide information about the health of the females of the population; specifically, about whether or not they are receiving adequate nutrition. However, keep in mind that most birds of the same species lay about the same number of eggs, but that the difference between clutch sizes may not be an indicator of health—it could be due to chance.

What is the independent variable in this experiment? It's the way in which the land is managed in each of the three areas. Remember that you cannot change the management practices; you have been given those.

What is the control in the experiment? This is a little less clear-cut. You're given three management plans, none of which operates on land that's left untouched. Therefore, you could set up a control at one of the reserves, but it might be difficult to attract hawks and start with an adequate base control number. Another option is to do a **library control.** In a library control, you could determine the maximum number of eggs and fledglings that could be expected based on data collected in previous years. Either one of these types of controls would be acceptable. Let's summarize the plan of action that you might propose.

You will grid off three random plots, each one acre in area, in each of the three management areas. You will then observe the hawks in these plots and determine the locations of their nests. You will examine each nest (using binoculars because the nests are usually high in trees) and determine the number of eggs in each clutch. You will continue to make observations throughout the summer to determine how many birds are hatched and how many live to the fledgling stage and leave the nest. You will statistically determine the percent success rate of each nest and the overall area to determine the success of the hawks. Then you will compare your data from the three areas.

So, the plan of action that you write in your exam booklet for answering the first parts of the question might include the following points:

Plan of Action

- Using library resources, determine the maximum success rate of offspring production in hawks (control).
- Plot out three one-acre, random plots on each of the three management areas.
- Survey plots for hawks and nests within each grid and record the locations of the nests.
- Count the number of eggs in each nest.
- Observe the nests and hatchlings, and count the number of hatched birds. Band baby birds for tracking purposes.
- Count the number of fledglings that survive and leave the nest.
- Perform statistical analysis to determine the success of the hawks on each of the three management areas.

The plan of action is your longest answer in this section, but hopefully you can see that it wasn't too difficult. You took the information you learned this year and applied it to the situation, but you didn't need to know much about hawks.

Unfortunately, however, the next parts will require you to know a little more, rather than just asking you to use your imagination. For example, part (c) asks you to describe how the land management plan of each of the three areas would affect the success of the hawk population.

Let's go through them one by one. The state land would be heavy in undergrowth and might have damaged trees located on it. The diversity of the plant population in this area would be relatively low because the grass would predominate—it would be able to grow unchecked. New grass would grow, but probably not many other plant species. On the other hand, the federal land is grazed, sod in this area there will be abundant growth of new grass. Also, due to this natural thinning of the grass, there will probably be some diversity in the vegetation, but without the fall grazing to clean up the dying grass and continue to thin it, it might not be as diverse as the fall grazed land. The private land can be grazed at any time. Controlled fires can also be used on this land to remove dead grass, add nutrients back into the soil, and remove some of the plant species that compete with grass, such as cactus or sage brush. For these reasons, the private land may have more diversity than any of the other land management areas.

You could also theorize that the private land could be overgrazed and thus exhibit low diversity. Really, you could make either presumption and be counted as correct. However, since you are given data on the fire practices and grazing, the first choice might be better. Why is the vegetation diversity important? The more vegetation diversity there is, the more choices for the herbivores in food and habitats—and probably the greater the success of the herbivore. In any event, the more successful the plants are, the more successful the herbivores in the area will be. Since hawks are carnivores, then the more successful the herbivores, the more successful the hawks. See how this line of reasoning naturally led to your answer to part (c)?

You're almost done; let's think about part (d). The success of the management plan would be demonstrated by the success of the hawk because the hawk is the tertiary consumer in the food chain. It cannot be successful if the rest of the food chain isn't strong.

You're done, and you really did not need to know much about the prairie or a hawk! What you did need to know was how to set up a field experiment; the concept of the food chain; and something about land management plans. Even the management plans could have been deducted with some critical thinking.

SOME COMMON AP ENVIRONMENTAL SCIENCE LABS

Below we've listed some of the common labs performed during an AP Environmental Science course, a summary of the procedures you might follow, and the take-home message of each.

Remember that each AP Environmental Science course is different; you may have performed some of these labs, but you have definitely not completed all of them. It's a good idea to review all of these labs and understand their basic workings as well as their intent.

Soil Analysis Lab

- Soil Testing Laboratory: In this lab soil is tested for physical traits and chemical properties, which provide information about the soil's condition and suitability for crops, septic fields, or other purposes. All of the factors tested are listed below.

  Chemical properties

  1. pH—Clay soil requires more lime (calcium oxide) or alum (aluminum sulfate) to alter its pH than do sandy or loam soils. Iron necessary for plant growth is unavailable when the soil becomes alkaline. Gymnosperms (pine, fir, etc.) grow better in mildly acidic soil.
  2. Nitrogen—common plant fertilizer component.
  3. Phosphorus—common plant fertilizer component.
  4. Potash—common name for a compound that contains one of the potassium oxides.

Physical characteristics

5. Soil type—sand, silt, clay—use mesh screen, cheese cloth, soil settling in water tubes to determine the percent of each type of particle in the sample.
6. Water-holding capacity—because of the small pores between clay particles, water moves very slowly through clay. Therefore, clay has a greater holding capacity than silt or sand.
7. Permeability—the movement of gas or liquid through the soil.
8. Friability—good soil is rich, light, and easily worked with fingers—this is good for plant growth because roots can easily grow through it.
9. Percent Humus—a measure of soluble organic constituents of soil—the higher the number, the better. Organic soil has qualities of both sand and clay. The small particles of organic soil come together to form larger clusters. Water can be retained inside a cluster, but can move between clusters to percolate. Organic material is also high in nutrients.
10. Buffering capacity of three different types of bedrock such as marble, granite, and basalt when exposed to acid. Marble has high calcium content and is a better buffer than other rocks.

Water Analysis Lab

- Water Chemical and Physical Analysis: Water can be tested from many different sources. Sample kits have tools for many different tests—for example, the LaMotte kit and the spectrophotometer type kit. Below are some commonly performed tests and some of the expected results. It is probably not necessary for you to memorize all the standards, but you should be familiar with them.

1. pH—normal pH of water is between 6.5–8.5.
2. DO—measure of dissolved oxygen in water. Warm-water fish require a minimum of 4 ppm and cold-water fish require 5 ppm.
3. Turbidity—measurement of water clarity. Higher turbidity means there will be low clarity and little sunlight will be able to penetrate the water. A Secchi Disk may be used to measure turbidity, but a more accurate measure can be made with a turbidity unit.
4. Phosphate—an important plant nutrient, typically found in fertilizer and runoff from agricultural lands. Too much leads to eutrophication of water, high BOD and low DO levels. Levels should not exceed 0.025 mg/L in still water and 0.05 mg/L in flowing water.
5. Alkalinity—measure of compounds that shift the pH towards the alkaline. There are no EPA standards, but normal is between 100–250 ppm.
6. BOD—biological oxygen demand, which is required for the aerobic organisms in a body of water. Unpolluted natural waters have a concentration of 5 mg/L or less. High nutrient levels are associated with high BOD and vice versa.

7. Chlorine—EPA standards dictate that Cl cannot exceed 250 mg/L. NaCl is applied to roads and parking lots and can run off into streams. Other sources of excess Cl are animal waste, potash fertilizer (KCl), and septic tank effluent. Chlorine is associated with limestone deposits but is not common in other soils, rocks, or minerals.
8. Hardness—a measure of salts composed of calcium, magnesium, or iron. Most water testing kits test for $CaCl_2$. Hard water is more than 121 ppm and soft water is less than 20 ppm.
9. Iron—normal range is 0.1–0.5 ppm.
10. Nitrates—as an important plant nutrient, nitrogen is typically found in fertilizer and is a component of runoff from agricultural lands. Too much leads to eutrophocation of water, high BOD and low DO levels. Over 0.10 mg/L is considered elevated and the EPA limit is 10 mg/L.
11. Total solids—weight of the suspended solids and dissolved solids. All natural waters have some suspended solids, but problem solids are sewage, industrial waste, or excess amounts of algae.
12. Total dissolved solids—naturally occurring in water, but may cause an objectionable taste in drinking water. They are also unsuitable for irrigation because they leave a salt residue on the soil. EPA standard is 500 mg/L, but dissolved solids may range from 20–2,000 mg/L.
13. Fecal Coliform—any bacteria that ferments lactose and produces gas when grown in lactose broth. New tests for this are performed by adding a water sample to a specialized media and observing color changes. Drinking water should show no colonies of growth from the water sample.

Air Quality Labs

- **Air Quality**: Air quality can be assessed using various methods.
- **Particulates**: Sticky paper can be used to collect air particulates from various sources, and then the paper can be examined under a microscope. It is not possible to see the smallest particulates, but they do color the white paper.
- **Ozone**: In this lab, an ecobadge or a homemade potassium iodide gel sampler is hung or worn in order to collect data on tropospheric ozone. The badge or KI sample changes color in the presence of ozone and becomes more intensely colored as the amount of ozone increases.
- **Carbon dioxide**: In this lab, a commercial sampling device is used to determine the amount of carbon dioxide in an air sample. Car exhaust, burning tobacco, or other pollutants can also be sampled.

OTHER LABS

- **Lichen**: A lichen survey can be used to judge air quality. Lichens are sensitive to air pollution, particularly sulfur dioxide. The most sensitive lichens are the fruticose types, followed by the foliose, and then the crusteous.

- **Scrubber model**: You may have constructed a model of a scrubber to attempt to remove sulfur contaminates from burning coal. You would have used a calcium compound to try to wash the contaminant from the air column.

- **Biodiversity of Invertebrates**: Insects can be counted in an area and then plotted to assess biodiversity. Traps such as fall traps or sticky traps can be set, and bait such as tuna or sugars can be used. The number of different insects captured could be counted, and this number divided into the total number captured would give an idea of the biodiversity of the area. A taxonomic key can be used to determine the number of species and their taxonomic name. A similar setup can be used to determine the impact of an invasive species. In this process, native bugs can be trapped and set up in terrariums; the invasive species is then introduced and the effects documented.

- **Field Trips**: Field trips can be taken to various areas of interest, such as power plants, landfills, or municipal waste treatment plants. The possibilities are almost endless. Think about what you learned from these experiences and how they can help you on this exam.

- **Energy audit**: In this lab, students are asked to use their homes as a laboratory and perform an energy audit, examining the amount of electricity used by their families over a set period of time and then using appliance standards to determine which is the largest energy consumer. A result of this lab is that students suggest how their family's electrical energy needs could be reduced.

- **Food chain**: In this lab, students observe a natural ecosystem and examine the food chain. They identify the organisms that are producers, primary consumers, and secondary consumers; and determine how many levels make up the food chain, what organisms act as decomposers, and the presence of symbiotic relationships.

- **Model Building**: In this lab, models are built to model land formations, coastlines, tectonic plates, mining operations, or any number of other physical formations. In modeling the tectonic plates, students can slide or bump together plate models that are lying on top of a viscous substance representing the magma. From this model, students see how subduction zones and volcanoes work. Other models also allow students to construct a representation of a physical structure in order to better understand that physical structure.

- **Mining**: Students can construct a model of a mine, representing the rock layers and the mineral deposits.

- **LC50** (or LD50): In this lab, students use a kit or a lab procedure to test the concentration (LC) or dose (LD) that would cause the death of 50 percent of a test organism. An example of this procedure is to test the effects of copper (common algaecide and fungicide ingredient) on Daphnia (a tiny species of freshwater crustacea). Daphnia are exposed to a range of Cu levels and then fed fluorescently-tagged sugar. Healthy Daphnia show up blue under UV light.

- **Population Density and Biomass:** This experiment can be performed in a number of different ways. One method is to mark off two plots, then remove all the vegetation from plot one. Plot two is left to grow for an additional period of time. This investigation may also be performed using grass squares in the lab or bottles of algae. The vegetation from plot one is dried and weighed. This provides the baseline data for the amount of biomass present at the beginning of the experiment. After the time period of growth for the second plot, the vegetation is removed from the second plot and treated as the first was. This provides information about the increase in biomass for the experimental time period. Another way this can be expressed is as the productivity of vegetation. By subtracting the initial growth (plot 1) from the experimental growth (plot 2), productivity could be calculated. This would constitute the net productivity for the plot. The grass in the second plot produced *X* amount of glucose (photosynthate). However, some of this photosynthate must be used to support the needs of the plant, so the number you calculate is the net, not the gross, productivity.

- **Gross and Net Productivity:** If an experiment is performed using bottles of growing algae or duckweed, the gross productivity can also be determined. One of the bottles in this experiment would contain the starting plant material, but instead of being exposed to light, it would be covered with foil to prevent light from entering the bottle. In this bottle, the plants are only able to perform respiration. Therefore, at the end of the experimental time, this bottle should have less biomass than the initial plant material because the plants had to use stored sugar for metabolic process. This would provide you with the metabolic rate information, which, when added to the net productivity, gives you the gross productivity.

- **Other Uses for Vegetation Plots:** Sample plots may be used to examine the biodiversity of vegetation or examine the patterns of plant growth or dispersal. For example, one species of plant can be marked in a plot, and unless a garden was used as the sample plot, the target plant would probably be dispersed in clumps. Remember that random dispersal is not typical in nature, and even distribution typically only occurs in plots planted by humans.

- **Population Growth:** Population growth experiments can involve fast-growing populations such as bacteria, duckweed (*Lemma minor*), rolly polies (sow bugs), or fruit flies (*Drosophila*); and can involve graphing, as does the analysis of human population data. Population growth can be graphed, with time along the *x*-axis and population growth on the *y*-axis. Initially, the curve is a J shape, but it becomes S-shaped. Bacterial growth curves have an extended hook on the J due to the lag time in growth as the bacteria acclimate to the new media.

- **Variables**: In population growth experiments, often other variables are added to samples of bacteria to compare the growth of a normal population to one that has been altered in some way. This can be used to assess the effect of extra nutrients, such as nitrogen or phosphorus, or the negative effects of certain substances on the organism.

- **Tubidity** and **Bacteria**: When studying bacteria, turbidity is commonly observed and recorded. The more turbid (cloudy) the tube, the more growth has taken place. Turbidity can be observed with a spectrophotometer. When the sample tube is inserted into the spectrophotometer, the instrument passes light through the sample tube and measures the amount of light that passed through or was absorbed.

- **Population Size**: In this type of lab, the size of a population of species such as the gypsy moth, caterpillar, or other insect is studied. Remember that a population is a group of individuals of the same species located in a given area. The experiment can involve a collection box and colored stickers that attract caterpillars. The first day, caterpillars are captured and marked. On the second day, the caterpillars are captured and the new and recaptured individuals are marked. By dividing the number of recaptured insects by the size of the population on day one, an estimate of the population that was originally captured can be obtained. On day three, the total number of caterpillars captured is counted. The total number of caterpillars captured on day three is divided by the calculated number from day two—this gives an estimate of the total population.

- **Salinization**: In this lab, students determine if and how salt levels retard seed germination. Students use various dilutions of salts (variety of salt types may be used) to saturate a growing surface. Seeds are sown to determine levels of salt that inhibit germination. This lab mimics what happens in irrigated farm land with salinization.

- **Note:** If you are asked to graph data on this exam, make sure you use reasonable units! Count the graph blocks you're given; this may help you determine an appropriate scale. Also remember that time is usually plotted on the *x*-axis.

Well, this marks the end of the content review for this exam—congratulations, you've finished! Study the words in the Hit Parade, which follows, and then take the practice exams. If you need extra practice, go through the sample multiple-choice and free-response questions that are offered on the College Board website.

Good luck!